Evaluation of the risk of incisional infection in horses following application of protective dressings after exploratory celiotomy for treatment of colic

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OBJECTIVE
To assess incidence of incisional infection in horses following management with 1 of 3 protective dressings after exploratory celiotomy for treatment of acute signs of abdominal pain (ie, colic) and determine the risk of complications associated with each wound management approach.

DESIGN
Prospective, randomized, controlled study.

ANIMALS
85 horses.

PROCEDURES
Horses were assigned to 3 groups. After standardized abdominal closure, a sterile cotton towel (group 1) or polyhexamethylene biguanide–impregnated dressing (group 2) was secured over the incision site with 4 or 5 cruciate sutures of nonabsorbable monofilament, or sterile gauze was placed over the site and secured with an iodine-impregnated adhesive drape (group 3).

Demographic and clinicopathologic data, intraoperative and postoperative variables, and development of complications were recorded and compared among groups by statistical methods. Follow-up information was collected 30 and 90 days after surgery. Incidence and odds of incisional complications were calculated.

RESULTS
75 horses completed the study. Group 3 typically had dressing displacement necessitating removal during anesthetic recovery; dressings were in place for a mean of 44 and 31 hours for groups 1 and 2, respectively. Purulent or persistent serosanguinous incisional discharge (ie, infection) was detected in 11 of 75 (15%) horses (2/24, 0/26, and 9/25 from groups 1, 2, and 3, respectively). Odds of incisional complications were significantly greater for group 3 than for groups 1 or 2.

CONCLUSIONS AND CLINICAL RELEVANCE
Results suggested that risk of infection after celiotomy for treatment of colic is lower for incisions covered with sterile towels or polyhexamethylene biguanide–impregnated dressings secured with sutures than for incisions covered with gauze secured with iodine-impregnated adhesive drapes. (J Am Vet Med Assoc 2019;254:1441–1447)

Although survival rates of horses following exploratory laparotomy for signs of acute abdominal pain (ie, colic) have significantly improved over the last 2 decades, postoperative incisional complications remain common. The incidence of these complications varies from 2.7% to 57% in the veterinary literature, with surgical factors such as suture pattern, suture material, degree of trauma to the surgical site, incision length, duration of surgery, and experience level of the surgeon associated (positively or negatively) with incisional complication rates. Incisional infections commonly develop in horses after repeated laparotomy, with reported rates as high as 13 of 17 (76%) in a recent study and 7 of 8 (88%) in a previous study.

Results of some studies have suggested that protection of the incision can help to prevent microbial contamination during recovery and the early postoperative period. A retrospective study found that the application of stent bandages was associated with a significantly lower incisional infection rate (2/75 [2.7%]), compared with that for horses that did not receive this treatment (12/55 [21.8%]).

Topically administered antimicrobials are commonly used in veterinary medicine in an effort to reduce the incidence of incisional infections. These should be nonirritating, nontoxic, and inexpensive and should have a wide spectrum of activity and a prolonged residual effect. A polymeric biguanide, PHMB has antimicrobial activity against gram-positive bacteria, antibiotic-resistant strains, and yeasts. PHMB possesses antiviral activity against herpes simplex virus types 1 and 2. PHMB is stable in the presence of a wide range of pH values. PHMB inhibits bacterial growth by interfering with bacterial cell membrane integrity. PHMB is bactericidal against methicillin-resistant Staphylococcus aureus, viridans streptococci, and Enterococcus faecalis. PHMB is fungicidal against Candida albicans. PHMB is also active against Mycobacterium tuberculosis and Mycobacterium avium.

ABBREVIATIONS
CI  Confidence interval
PHMB  Polyhexamethylene biguanide
and gram-negative bacteria; it causes disruption of bacterial cytoplasmic membranes with eventual leakage and precipitation of cell contents and is rapidly bactericidal at high concentrations.11,12 Rolled cotton gauze impregnated with 0.2% PHMB was developed as a means of reducing bacterial growth in bandaged wounds. Results of an in vitro study12 indicated that PHMB-treated gauze inhibited growth of several bacterial species from veterinary patients when the dressing was placed on inoculated agar plates; in particular, wet-inoculated PHMB dressings inhibited growth of Escherichia coli, Enterobacter aerogenes, and all gram-positive bacteria tested. To the authors’ knowledge, there is a paucity in the literature regarding the use of this PHMB-impregnated gauze in horses and no previous study evaluating its use to protect ventral midline incisions in horses undergoing surgery.

The purpose of the study reported here was to compare incisional complication rates in surgical wounds of horses managed with 3 types of protective dressings, including a PHMB-impregnated gauze dressing, following exploratory celiotomy with a ventral midline approach for treatment of signs of abdominal pain (ie, colic). We hypothesized that use of PHMB-impregnated rolled gauze would result in a reduced incidence of incisional infection, compared with that observed with the use of a sterile towel dressing or a sterile gauze pad covered with iodine-impregnated adhesive drape.

Materials and Methods

Study design and procedures

Horses that underwent exploratory celiotomy for treatment of colic at the William R. Pritchard Veterinary Medical Teaching Hospital of the University of California-Davis between July 1, 2014, and January 31, 2016, were eligible for inclusion in the prospective study. To be retained in the study, horses had to have undergone a ventral midline celiotomy that included a standardized protocol for closure of the abdomen, to have survived ≥ 90 days after surgery, and to have follow-up information available from the owner or referring veterinarian 30 and 90 days after surgery (with the day of surgery considered day 0). Horses that underwent surgery more than once and those that were < 1 year of age or weighed < 350 kg (< 770 lb) were excluded from the study. The study was approved by the university’s clinical trial review board. All study methods were considered to meet the standard of care, and written owner consent for study inclusion was not required.

All horses received perioperative antimicrobial (penicillin G procaine [22,000 U/kg {10,000 U/lb}, IM] and gentamicin sulfate [6.6 mg/kg {3 mg/lb}, IV]) and anti-inflammatory (flunixin meglumine [1.1 mg/kg {0.5 mg/lb}, IV]) medications. Prophylaxis against tetanus was also administered when appropriate. A standard protocol for closure of the abdomen was used for all horses included in the study. The linea alba was closed with size-3 absorbable multifilament suture (polyglandin 910P) in a simple continuous pattern. Following closure of the abdominal wall, lavage was performed with sterile saline (0.9% NaCl) solution, the site was blotted dry with sterile gauze, and 1 g of ceftazolin powder was applied. The subcutaneous layer was then apposed with 2-0 absorbable monofilament (polyglycaprone6) suture in a simple continuous pattern, and the skin was apposed with stainless steel skin staples.

Horses were randomly assigned to 3 postoperative treatment groups. Assignment was performed by computer software.5 Group 1 horses had a sterile towel placed over the abdominal incision and secured with 4 or 5 cruciate sutures of size-2 nonabsorbable monofilament (polypropylene5). Group 2 horses had a PHMB-impregnated dressing placed over the incision and secured with 4 or 5 cruciate sutures of size-2 nonabsorbable monofilament. Group 3 horses had sterile gauze placed over the incision that was then covered with an iodine-impregnated adhesive drape.6 To improve adhesion of the iodine-impregnated drape, an adhesive spray was used on the skin circumferentially around the incision before application.

The dressings used to cover incisions were removed at the clinician’s discretion if they became dislodged (including dislodgment during recovery), soiled, or wet. The time of dressing removal was measured from the end of surgery (ie, time of placement of the last suture) and recorded in the medical record.

Standard medical treatment consisted of antimicrobial administration (penicillin G procaine [22,000 U/kg, IM, q 12 h] and gentamicin sulfate [6.6 mg/kg, IV, q 24 h for ≥ 48 hours and anti-inflammatory treatment (flunixin meglumine at a tapering dose) for 7 to 10 days, depending on clinician preference. A constant rate IV infusion of lidocaine (0.05 mg/kg/min [0.02 mg/lb]) was administered at the clinician’s discretion. Horses deemed to be at risk for endotoxemia were administered polymixin B (3,000 to 5,000 U/kg [1,364 to 2,273 U/lb], IV, q 12 h) and DMSO (10 mL in 1 L of lactated Ringer solution, IV, q 12 h) according to clinician preference.

Data collection

Preoperative data obtained from the medical records included age, sex, breed, heart rate, rectal temperature, blood lactate concentration, total nucleated cell count, PCV, and serum total protein concentration. For patients that had abdominocentesis performed, the peritoneal fluid lactate concentration, total protein concentration, and nucleated cell count were also recorded. Surgery performed between 5 PM and 9 AM or during a weekend or holiday was categorized as taking place outside of normal working hours. The season in which surgery took place was categorized as spring (March 1 through May 31), summer (June 1 through August 31), fall (September 1 through November 30) and winter (December 1 through February 28).
Intraoperative data collected included the length of the ventral midline incision, the primary lesion identified, performance of an enterotomy, performance of a resection and anastomosis, duration of the surgery (measured from the time of first incision until the last suture was placed), house officers and surgeon involved in closure of the abdomen, type of incisional protection used, placement of an abdominal drainage tube, and duration of anesthesia (measured from induction to the time when a horse was moved to the recovery stall). The length of the incision was measured at the end of surgery by the primary surgeon. Postoperative data collected included time of dressing removal, any complications encountered, and duration of hospitalization. Postoperative colic was defined as episodes of abdominal pain necessitating analgesic treatment. Postoperative ileus was identified when horses had reflux on passage of a nasogastric tube and was defined as > 2 L of net reflux on 2 separate occasions. Fever was defined as a rectal temperature of > 38.6°C (> 101.5°F). The following outcomes were defined as incisional complications: any abnormal drainage from the incision, acute dehiscence of the incision, and ventral midline hernia formation. Serous drainage from the incision limited to the within the first 24 hours after surgery was classified as normal. Surgical site infection was defined as any purulent or serous discharge from the incision > 24 hours after the end of surgery. Treatment that was undertaken and outcome were recorded. Results of culture for incisional drainage samples and susceptibility testing of any isolates obtained were recorded when this was performed.

Follow-up information was obtained by telephone conversation with the owner or referring veterinarian 30 and 90 days after surgery to ascertain whether any incisional complications occurred. The data were collected by one of the authors (IK) or 1 hospital employee using a standardized questionnaire. Information solicited included whether the horse had developed any incisional drainage after discharge and if so, what the nature of the discharge was, how was it treated, and whether it had resolved. Other information obtained included whether there was a palpable defect at the site of the incision (ie, an incisional hernia) and whether the horse developed any other complications.

Statistical analysis
Summary statistics were calculated for all variables. Signalment (age, sex, and breed), body weight, physical examination findings, and surgical findings were compared among the 3 postoperative treatment groups with a χ² test or 1-way ANOVA for categorical and continuous data, respectively. Exact logistic regression was used to determine the odds of developing incisional complications < 30 days after surgery among the treatment groups; ORs and 95% CIs were calculated for 3 time categories (early [< 30 days], late [30 to 90 days], and any time [≥ 90 days]). Factors (age, body weight, clinicopathologic data, incision length, surgery and anesthesia time, presence of a strangulating lesion, performance of an enterotomy or resection and anastomosis, and development of postoperative reflux, fever, incisional edema, or signs of pain on palpation of the incision) were assessed for association with incisional complications by use of a χ² test or Student t test for categorical and continuous data, respectively. All statistical analyses were performed with a commercial statistical software program.b Values of P ≤ 0.05 were considered significant.

Results
Eighty-five horses were initially enrolled in the study; of these, 10 were removed and excluded from the analyses. These included 4 horses that were euthanized while hospitalized after surgery, 4 that underwent repeat celiotomy, 1 that was euthanized < 90 days after hospital discharge, and 1 that was lost to follow-up. Seventy-five horses were retained in the study (24 that had a sterile towel secured over the incision with suture [group 1], 26 that had a PHMB-impregnated dressing secured over the incision with suture [group 2], and 25 that had sterile gauze placed over the incision and secured with an iodine-impregnated adhesive drape [group 3]).

The breeds represented included American Quarter Horse (31/75 [41%]), Thoroughbred (8 [11%]), Arabian (8 [11%]), American Paint Horse (4 [5%]), Friesian (4 [5%]), Morgan (3 [4%]), Appaloosa (2 [3%]), Tennessee Walking Horse (2 [3%]), Pinto (1 [1%]), Saddlebred (1 [1%]), Standardbred (1 [1%]), Percheron (1 [1%]), and Haflinger (1 [1%]). Seven (9%) were warmblood-type horses, and 1 (1%) was listed as a pony without breed details. The mean age of horses at the time of hospital admission was 14 years (median, 14 years; range, 2 to 29 years). The mean weight of these horses was 515 kg (1,133 lb). There were no significant differences in age, sex, body weight, or clinicopathologic variables among the 3 study groups (Table 1). Whether surgery was performed on an emergency basis (ie, outside of normal working hours) did not differ significantly among groups. Surgeries were performed by 1 of 3 senior clinicians accompanied by 1 or 2 house officers (5 house officers in total).

Purulent or persistent sanguinous discharge present ≥ 24 hours after surgery (ie, infection) was observed for 11 of 75 (15%) horses before or after discharge from the hospital (2 of group 1 and 9 of group 3). There was no significant difference in the examined variables between horses that developed incisional drainage and those that did not.

None of the horses that developed incisional infection developed a hernia. However, 2 other horses (1 from group 1 and 1 from group 3) had small hernias present at the 90-day follow-up. Neither of these 2 horses had evidence of incisional abnormalities while in the hospital nor at the 30-day follow-up. The
Table 1—Comparison of mean ± SD values for continuous variables (age, body weight, clinico-pathologic, and surgical data) for 75 horses in a study to compare incisional complication rates following management with 1 of 3 different protective dressings after exploratory celiotomy with a ventral midline approach for treatment of acute signs of abdominal pain (ie, colic).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group 1 Mean ± SD</th>
<th>Group 2 Mean ± SD</th>
<th>Group 3 Mean ± SD</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>13.3 ± 6.6</td>
<td>13.5 ± 4.9</td>
<td>14.0 ± 7.4</td>
<td>0.93</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>493 ± 81</td>
<td>534 ± 71</td>
<td>518 ± 75</td>
<td>0.16</td>
</tr>
<tr>
<td>Heart rate (beats/min)</td>
<td>46 ± 10</td>
<td>51 ± 14</td>
<td>47 ± 10</td>
<td>0.38</td>
</tr>
<tr>
<td>Rectal temperature (°C)</td>
<td>37.5 ± 0.5</td>
<td>37.4 ± 0.6</td>
<td>37.2 ± 0.9</td>
<td>0.54</td>
</tr>
<tr>
<td>PCV (%)</td>
<td>33.5 ± 5.7</td>
<td>36.4 ± 5.4</td>
<td>36.9 ± 5.9</td>
<td>0.08</td>
</tr>
<tr>
<td>Serum total protein (g/dL)</td>
<td>6.6 ± 0.6</td>
<td>6.6 ± 0.6</td>
<td>6.6 ± 0.7</td>
<td>0.97</td>
</tr>
<tr>
<td>Total nucleated cell count (cells/μL)</td>
<td>7,310 ± 2,570</td>
<td>8,200 ± 2,700</td>
<td>8,290 ± 1,900</td>
<td>0.31</td>
</tr>
<tr>
<td>Blood lactate (mmol/L)</td>
<td>2.7 ± 2.7</td>
<td>1.7 ± 1.4</td>
<td>2.6 ± 2.5</td>
<td>0.24</td>
</tr>
<tr>
<td>Peritoneal fluid lactate (mmol/L)</td>
<td>2.7 ± 2.4</td>
<td>2.0 ± 1.6</td>
<td>3.7 ± 2.8</td>
<td>0.08</td>
</tr>
<tr>
<td>Peritoneal fluid nucleated cell count (cells/μL)</td>
<td>9,690 ± 25,660</td>
<td>1,440 ± 1,270</td>
<td>2,090 ± 2,570</td>
<td>0.19</td>
</tr>
<tr>
<td>Peritoneal fluid total protein (g/dL)</td>
<td>1.9 ± 0.8</td>
<td>2.1 ± 0.9</td>
<td>2.3 ± 1.0</td>
<td>0.46</td>
</tr>
<tr>
<td>Incision length (cm)</td>
<td>24.0 ± 3.5</td>
<td>23.5 ± 3.7</td>
<td>24.2 ± 5.8</td>
<td>0.87</td>
</tr>
<tr>
<td>Surgical time (min)</td>
<td>133 ± 59</td>
<td>123 ± 39</td>
<td>117 ± 35</td>
<td>0.48</td>
</tr>
<tr>
<td>Anesthesia time (min)</td>
<td>163 ± 59</td>
<td>157 ± 40</td>
<td>152 ± 39</td>
<td>0.70</td>
</tr>
</tbody>
</table>

Group 1 (n = 24) had a sterile cotton towel placed over the abdominal incision and secured with 4 to 5 cruciate sutures of size-2 nonabsorbable monofilament suture. Group 2 (n = 26) had a PHMB-impregnated dressing placed over the incision and secured in the same manner as for group 1. Group 3 (n = 25) had sterile gauze placed over the incision and covered with an iodine-impregnated adhesive drape. Values of P < 0.05 were considered significant for all statistical comparisons.

The odds of developing an incisional infection or hernia at any time after surgery were significantly greater for horses of group 3 than for horses of group 1 (OR, 6.187 [95% CI, 1.174 to 32.607]; P = 0.032) or group 2 (OR, 18.593 [95% CI, 2.674 to ∞]; P = 0.001).

Seven of 11 horses that developed incisional infection had surgery in the winter, 3 underwent surgery in the summer, and 1 underwent surgery in the spring. Of these 11 horses, only 2 had drainage indicative of infection observed while hospitalized. The mean ± SD time to development of incisional infection was 14 ± 5 days. Culture and susceptibility testing of isolates were performed for 3 of the horses, including the 2 that developed infection while hospitalized. A mixed growth of bacteria was observed in samples from all 3 horses; isolates included *Aerococcus viridans*, *Bacteroides fragilis*, *Enterococcus faecium*, *Enterococcus faecalis*, *E coli*, *Morganella morganii*, and *Enterobacter cloacae*. These 3 horses had resolution of the complication with systemic antimicrobial treatment selected on the basis of susceptibility testing results. Four other horses that did not have culture of a fluid sample performed were treated with orally administered broad-spectrum antimicrobials by the referring veterinarian. The 4 remaining horses had local wound treatment with removal of staples to facilitate drainage and cleaning but did not have systemic antimicrobial treatment. These 8 horses also responded to the selected treatment, and signs of infection resolved. All incisions were healed at the 90-day follow-up.

**Discussion**

Results of the present study indicated that placement of a sterile towel or a PHMB-impregnated protective dressing secured with sutures over the incision site was associated with significantly lower odds of incisional infection (defined as purulent or serosanguinous drainage from the surgical wound ≥ 24 hours after surgery ended) and significantly lower odds of hernia development in horses following exploratory celiotomy for treatment of signs of acute abdominal pain (ie, colic), compared with the odds for horses that had sterile gauze placed over the wound and secured with an iodine-impregnated adhesive drape. The odds of horses that had gauze and iodine-impregnated drape treatment (group 3) developing...
one of these complications were 18 times those for horses that had the PHMB-impregnated dressing applied (group 2) and 6 times those for horses that had the sterile towel applied (group 1).

The overall rate of incisional infection in the present study (11/75 [15%]) was lower than that described in other studies.\textsuperscript{1,2,4,9,14,15} Fifty horses in the study had some type of protective dressing placed over the incision site and secured with sutures (24 and 26 in groups 1 and 2, respectively), and only 2 of 50 (4%) developed an incisional infection, compared with 9 of 25 (36%) horses that had the dressing secured with an adhesive drape. These findings were similar to those of another study\textsuperscript{8} in which application of stent bandage was associated with a lower incisional infection rate (2/75 [2.7%]), compared with results for horses that did not have a stent bandage (12/55 [21.8%]). Conversely, an investigation by Mair and Smith\textsuperscript{16} in 2005 found that application of a stent bandage was associated with a higher rate of wound complications than if no stent was applied; however, the authors believed that this result may have been influenced by patient selection (ie, use of the stent bandage when incisional complications were anticipated). In that study,\textsuperscript{16} stent bandages were typically left in place for 3 days, which might have increased the risk of wound infection.

To the author’s knowledge, our study was the first prospective, controlled investigation to examine the effects of different protective dressings on development of incisional complications in horses following colic surgery. Only horses > 1 year of age were included in the study. All horses underwent the same preoperative skin preparation and draping procedures; all had the same 3-layer closure of the ventral midline, subcutaneous tissue, and skin performed with the same materials; and all underwent lavage of the ventral midline following closure\textsuperscript{9} and application of 1 g of cefazolin prior to closure of the subcutaneous tissue. This standardization of the protocol to the furthest extent possible was an effort to reduce the possibly confounding effects of these variables to allow better assessment of the 3 dressing types used.

The use of PHMB-impregnated dressings has been shown to prevent growth of bacterial pathogens and may be especially useful for preventing introduction of bacteria into wounds.\textsuperscript{12,17} Results of a study\textsuperscript{37} to investigate the rates of surgical site infection in a human hospital setting when use of sterile plain gauze dressings was replaced with the use of comparable sterile gauze dressings impregnated with 0.2% PHMB demonstrated that, prior to introduction of the PHMB-impregnated dressing, 101 surgical site infections developed after 9,372 (1.08%) surgeries (including 20 [0.21%] infections with methicillin-resistant \textit{Staphylococcus aureus}). After introduction of the PHMB-impregnated dressing, 84 surgical site infections developed after 10,202 (0.82%) surgical procedures, representing a significant reduction in the rate of local infections.\textsuperscript{17} Additionally, after introduction of the PHMB-impregnated dressing, 11 of the 10,202 (0.11%) procedures resulted in surgical site infection with methicillin-resistant \textit{S. aureus}, representing a significant reduction in the rate of infections with this pathogen.\textsuperscript{17} In horses, the use of PHMB-impregnated dressings has been reported for application on wounds of the face and distal aspects of the limbs,\textsuperscript{18-20} but to the authors’ knowledge, no controlled study has been previously performed to assess the use of these dressings following abdominal surgery in horses. There were no complications attributable to the use of these dressings in our study; however, 1 review\textsuperscript{21} identified inflammation of wounds and increased wound healing time when these were used as the primary dressing layer. Although no obvious complications were noted for horses that were treated with this PHMB-impregnated dressing, differences in wound healing time or the direct presence of inflammation was not evaluated in the present study. Another concern would be whether the use of these antimicrobial impregnated dressings selects for antimicrobial resistance.\textsuperscript{12} Although associations have been reported between bacterial susceptibility to antimicrobials and the use of biguanide chlorhexidine,\textsuperscript{22-24} to the authors’ knowledge, similar findings regarding PHMB have not been reported, and this is a subject that warrants future research.

Interestingly, in our study only 2 of 12 horses developed drainage indicative of incisional infection while in the hospital. The mean time to the development of this drainage was 14 days, which emphasized the need for prolonged follow-up with the referring veterinarian and owner in identifying these cases. It is possible that previous studies\textsuperscript{15} in which follow-up was limited to a shorter period of time may have underestimated their incisional complication rate on the basis of these findings.

All the horses that developed incisional infections responded to appropriate treatment, and incisions had healed at the 90-day follow-up. None of the horses with incisional infections developed a hernia, although 2 other horses were noted to have developed a small hernia at (but not before) the 90-day follow-up. We speculate that these horses had small defects that were not obviously detectable but were noted as the owners were specifically checking the ventral midline as part of the study.

Results of a recent study\textsuperscript{15} indicated that the most common isolates from incisional infections following exploratory laparotomy in horses were \textit{E. coli}, \textit{Enterococcus} spp, and \textit{Staphylococcus} spp. In the present study, microbial culture results were available for only 3 of 11 horses with incisional infection, and mixed growth of bacteria was identified including \textit{A. viridans}, \textit{B. fragilis}, \textit{E. faecium}, \textit{E. faecalis}, \textit{E. coli}, \textit{M. morgani}, and \textit{E. cloacae}; these likely represented opportunistic infections from the environment. The intraoperative application of cefazolin, a first-generation cephalosporin, might have prevented infection by susceptible bacteria. However, all bacteria that were cultured from these 3 horses showed resistance to this drug by susceptibility testing, which could make its...
use controversial. Mair and Smith\textsuperscript{16} reported that only 55 of 208 (26.4\%) horses in their study had developed incisional complications when benzyl penicillin was used topically, compared with 18 of 44 (41\%) in the absence of this treatment. Another study\textsuperscript{3} to investigate the rate of surgical site infection in horses when skin staples were used found local application of penicillin G to the linea alba to be protective. In that same study,\textsuperscript{3} most of the pathogens isolated from culture-positive horses were resistant to this antimicrobial. As surgeons, we need to be cognizant of our antimicrobial use to avoid the development of antimicrobial resistance, especially in a hospital environment.

Results of a 2015 study\textsuperscript{15} indicated that horses were more likely to develop incisional infection when laparotomy was performed in the summer or winter months than when it was performed the spring and fall months. The authors hypothesized that a thicker coat during the winter months might contribute to greater environmental contamination and that higher ambient temperatures during the summer months could provide an optimum environment for bacteria to colonize an abdominal incision. Interestingly, 7 of 11 horses in our study that developed incisional infection had surgery in the winter months and 3 underwent surgery in the summer months.

It is important to note that the timing of dressing removal (≤ 1 or > 1 hour after surgery) was significantly associated with the development of incisional complications in our study and was likely a confounding factor. Most of the dressings secured with iodine-impregnated adhesive drapes were dislodged during recovery from anesthesia, necessitating removal. Unfortunately, the number of these dressings that were dislodged during recovery was not recorded, and this was a major limitation of the study. Two horses in group 1 and another 2 horses in group 2 had the protective dressing removed 1 hour after surgery and did not develop incisional complications.

Additionally, there was a subjective difference in removal times between the group 1 and 2 dressings, although these were not analyzed statistically. In general, the PHMB-impregnated dressing was removed for group 2 horses earlier than the sterile towel dressing was removed for group 1 horses. The cotton towel used was more substantial than the PHMB-impregnated gauze dressing, with a wider diameter, and therefore we believe that it was likely more absorbent, allowing it to be left in place longer.

Other limitations of this study included that it was performed at only 1 veterinary hospital with a limited number of horses enrolled, which may have reduced the statistical power of the study. Although there were only 3 faculty surgeons involved in all cases, there was a number of different house officers who would have been involved in abdominal closure during the study period. Also, because drainage indicative of incisional infection developed after hospital discharge in most cases, culture results were lacking for 8 of the 11 affected horses.

On the basis of results of the present study, we recommend the use of any sterile protective dressing that is sutured over the incision for horses after exploratory laparotomy for treatment of colic as a potential means of reducing the incidence of incisional infections, compared with the use of an adhesive dressing. There were no adverse effects attributable to the PHMB-impregnated dressing for this short-term application (ie, ≤ 48 hours), and we consider that this may be useful as a protective dressing, although further research is needed to determine the most appropriate situations and duration for its use.

Footnotes

a. Coated Vicryl, Ethicon, Johnson & Johnson Inc, Markham, ON, Canada.
b. Monocryl, Ethicon, Johnson & Johnson Inc, Markham, ON, Canada.
d. Prolene, Ethicon, Johnson & Johnson Inc, Markham, ON, Canada.
f. Ioban 2, 3M Medical-Surgical Division, Saint Paul, Minn.
g. Adapt Medical Adhesive, Hollister Inc, Libertyville, Ill.
h. Stata, version 15.0, StataCorp, College Station, Tex.

References

Radiation exposure of dogs and cats undergoing fluoroscopic procedures and for operators performing those procedures

Rebecca A. Hersh-Boyle et al

OBJECTIVE
To evaluate radiation exposure of dogs and cats undergoing procedures requiring intraoperative fluoroscopy and for operators performing those procedures.

SAMPLE
360 fluoroscopic procedures performed at 2 academic institutions between 2012 and 2015.

PROCEDURES
Fluoroscopic procedures were classified as vascular, urinary, respiratory, cardiac, gastrointestinal, and orthopedic. Fluoroscopy operators were classified as interventional radiology–trained clinicians, orthopedic surgeons, soft tissue surgeons, internists, and cardiologists. Total radiation exposure in milligrays and total fluoroscopy time in minutes were obtained from dose reports for 4 C-arm units. Kruskal-Wallis equality of populations rank tests and Dunn pairwise comparisons were used to compare differences in time and exposure among procedures and operators.

RESULTS
Fluoroscopy time (median, 35.80 minutes; range, 0.60 to 84.70 minutes) was significantly greater and radiation exposure (median, 137.00 mGy; range, 3.00 to 617.51 mGy) was significantly higher for vascular procedures than for other procedures. Median total radiation exposure was significantly higher for procedures performed by interventional radiology–trained clinicians (16.10 mGy; range, 0.44 to 617.50 mGy), cardiologists (25.82 mGy; range, 0.33 to 287.45 mGy), and internists (25.24 mGy; range, 3.58 to 185.79 mGy).

CONCLUSIONS AND CLINICAL RELEVANCE
Vascular fluoroscopic procedures were associated with significantly longer fluoroscopy time and higher radiation exposure than were other evaluated fluoroscopic procedures. Future studies should focus on quantitative radiation monitoring for patients and operators, importance of operator training, intraoperative safety measures, and protocols for postoperative monitoring of patients. (Am J Vet Res 2019;80:558–564)